UNCLASSIFIED

CONFIDENTIAL

Copy No.
RM No. L8E14

NACA RM No. L8E14

28 JUN 1948

NACA

RESEARCH MEMORANDUM

LIMITED MEASUREMENTS OF STATIC LONGITUDINAL STABILITY IN FLIGHT OF DOUGLAS D-558-1 AIRPLANE

(BUAERO NO. 37971)

By

Walter C. Williams

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

CLASSIFICATION CANCELLED

CLASSIFIED DOCUMENT

Authority NACA R7 2382 Date 8/18/54

By NA 8/31/54 See

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON
June 24, 1948

UNCLASSIFIED

CONFIDENTIAL

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

LIMITED MEASUREMENTS OF STATIC LONGITUDINAL STABILITY IN FLIGHT OF DOUGLAS D-558-1 AIRPLANE (BUAERO NO. 37971)

By Walter C. Williams

SUMMARY

During airspeed calibration flights of the D-558-1 airplane being used by NACA for high-speed-flight research, some measurements were obtained of the static longitudinal stability up to a Mach number of 0.85. These data showed that the airplane possessed positive static longitudinal stability up to a Mach number of 0.80. A trim change in the nose-down direction occurred for Mach numbers above 0.82.

INTRODUCTION

The NACA is engaged in a flight-research program in the transonic speed range utilizing two Douglas D-558-1 airplanes. One of these airplanes (BuAero No. 37971) is being used for investigation of stability and control characteristics and over-all aerodynamic loads. The other airplane (BuAero No. 37972) is being used for measurements of the pressure distribution over the wing and horizontal tail. The present report covers results of brief measurements of the static longitudinal stability obtained during the airspeed calibration flights of the D-558-1 airplane used for stability and control measurements.

SYMBOLS

q_c impact pressure, pounds per square foot

M Mach number

δ_e elevator deflection, degrees

F_e elevator force, pounds

i_t stabilizer incidence, degrees

c_w wing chord, feet

[redacted]

AIRPLANE

The Douglas D-558-1 airplane is a single-place low-wing monoplane powered by a single General Electric TG-180 turbojet engine. General views of the airplane are given in figures 1(a), (b), and (c). A three-view layout of the airplane is given in figure 2. For the data presented herein the center of gravity was located at 25.7 percent mean aerodynamic chord and the gross weight was 10,258 pounds at take-off. Detail specifications of the airplane are given in table I.

INSTRUMENTATION

Standard NACA recording instruments are used to measure the various quantities necessary to determine the stability and control characteristics of the subject airplane. In addition, a Consolidated oscillograph is installed to record the loads as measured by the strain gages installed in the wing and horizontal tail. All records are synchronized by means of a common timing circuit. The instruments used and the quantities measured follow:

Recording instrument	Quantity measured
Airspeed-altitude recorder	Indicated airspeed, pressure altitude
Three-component accelerometer	Normal, longitudinal, and transverse acceleration
Angular-velocity recorder	Rolling velocity
Sideslip-angle recorder	Sideslip angle
Wheel-force recorder	Aileron and elevator force
Pedal-force recorder	Rudder-pedal force
Control-position recorder	Aileron, elevator, rudder, and stabilizer position
Consolidated oscillograph	Wing bending moment and shear load, horizontal-tail shear load
Timer	Time

The vane used with the sideslip-angle recorder is mounted a distance of 1 chord ahead of the left wing tip. The airspeed head was mounted on a boom on the right wing tip of such length that the static orifices are 1-chord length ahead of the wing leading edge.

TESTS, RESULTS, AND DISCUSSION

The results of the airspeed calibration flights made on the D-558-1 airplane have not been completely evaluated as yet. The results of a calibration of the error in static pressure made by flying past a reference landmark indicate, however, that the error in measured static pressure is of the order of $0.01q_c$ up to a Mach number of 0.78. Results of airspeed calibrations of the XS-1 which has a similar installation indicate that the error in Mach number up to $M = 0.85$, the limit of the present tests, is of the order of 1 percent or less (reference 1). The Mach numbers used in the present paper are those obtained from recorded pressures with no correction for static error applied.

Figure 3 presents the variation of elevator position and force required for trim with Mach number as obtained in runs made by increasing power as the speed was increased from approximately $M = 0.55$ to $M = 0.85$ at 30,000 feet pressure altitude so that the power used was essentially that required for level flight. Data were obtained at two stabilizer settings but these settings were close enough to the same value that it is difficult to determine any value of relative elevator effectiveness. Also, no elevator-position data with the stabilizer set at 2.32° were obtained above $M = 0.80$ because the recorder ran out of film. The data in figure 3 do show, however, that up to a Mach number of about 0.80 the airplane possesses positive longitudinal stability stick fixed and free. Above a Mach number of 0.82, there is a trim change in the nose-down direction which is the first manifestation of compressibility effects in level flight with this airplane. This trim change is similar to that measured on the XS-1 airplane (reference 1).

CONCLUSIONS

The results of measurements of the elevator angle and force required for trim at Mach numbers up to 0.85 show that below a Mach number of 0.80 the D-558-1 airplane possesses positive static longitudinal stability. Above a Mach number of 0.82, there is a nose-down trim change.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCE

1. Drake, Hubert M., McLaughlin, Milton D., and Goodman, Harold R.: Results Obtained During Accelerated Transonic Tests of the Bell XS-1 Airplane in Flights to a Mach Number of 0.92. NACA RM No. L8A05a, 1948.

TABLE I

PHYSICAL CHARACTERISTICS OF DOUGLAS D-558-1 AIRPLANE

Wing:	
Area, sq ft	150.7
Span, ft	25
Taper ratio	0.54
Aspect ratio	4.17
Root section	NACA 65-110
Tip section	NACA 65-110
Sweepback of 50-percent chord line	0
Geometric dihedral, deg	4.0
Incidence at root chord, deg	2.0
Geometric twist	0
Mean aerodynamic chord, ft	6.21
Ailerons:	
Area aft hinge line (both ailerons), sq ft	7.94
Mean aerodynamic chord, ft	0.772
Span (one side), ft	5.19
Hinge-line location (percent c_w)	85
Horizontal tail:	
Area, sq ft	35.98
Span, ft	12.25
Aspect ratio	4.17
Taper ratio	0.55
Tail length, from $0.25c_w$ to elevator hinge line, ft	16.34
Elevators:	
Area aft of hinge line (both sides), sq ft	8.6
Span (one side), ft	5.91
Hinge location, percent horizontal-tail chord	75
Mean aerodynamic chord, ft	0.75
Vertical tail surface:	
Area, sq ft	25.68
Span, ft	5.55
Aspect ratio	1.20
Taper ratio	0.56
Fin offset	0
Tail length, from $0.25c_w$ to rudder hinge line, ft	17.38
Dorsal-fin area, sq ft	9.08
Rudder:	
Area aft of hinge line, sq ft	7.92
Span, ft	5.67
Mean aerodynamic chord, ft	1.44

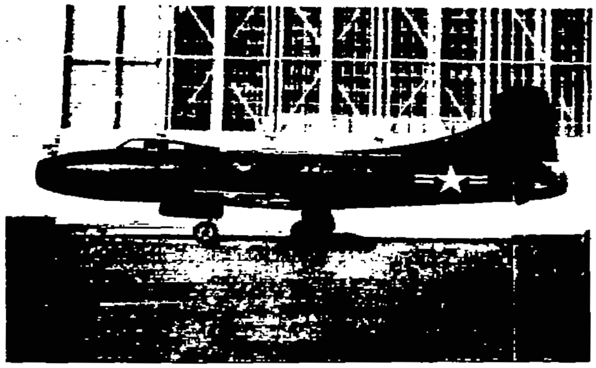
TABLE I - Concluded

PHYSICAL CHARACTERISTICS OF DOUGLAS D-558-1 AIRPLANE - Concluded

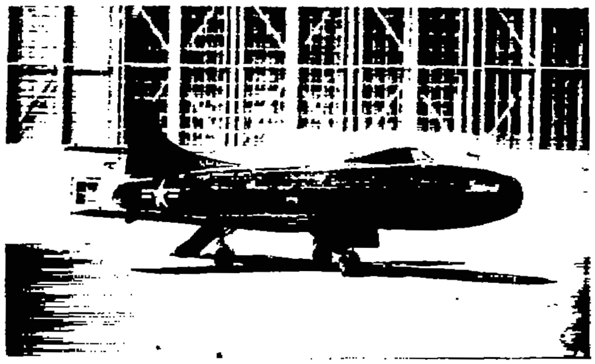
Fuselage:

Fuselage length, ft	35.04
Fuselage depth (maximum), ft	4.0
Fuselage width (maximum), ft	4.0

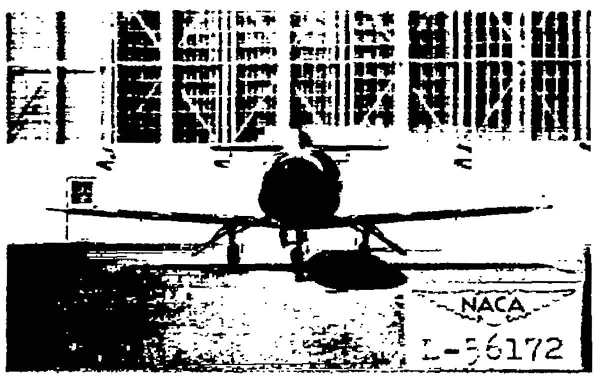
[redacted]



(a) Side view.



(b) Three-quarter front view.

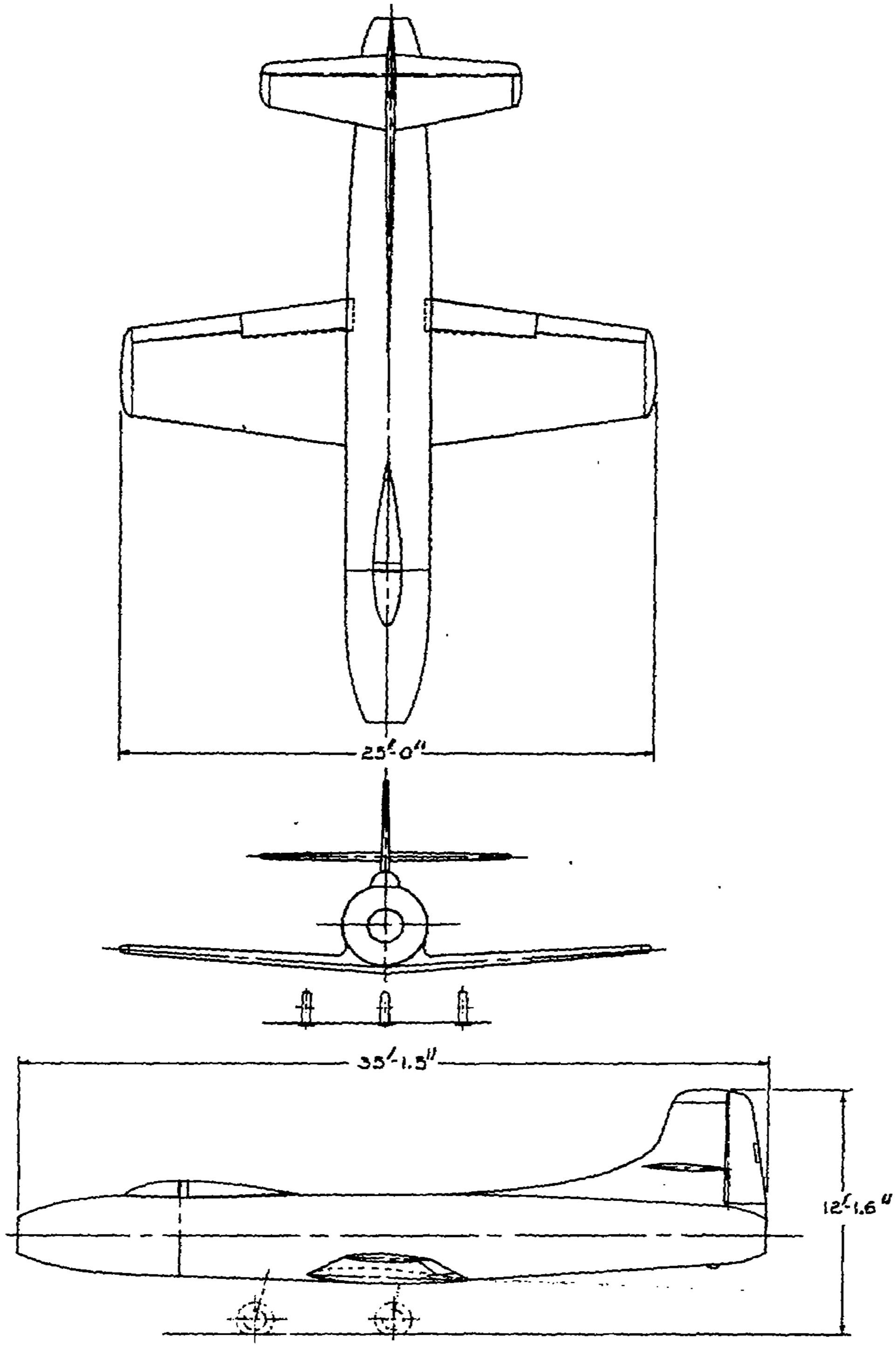


(c) Front view.

Figure 1.- Photographs of D-558-1 airplane.

[redacted]

[redacted]



[redacted]

Figure 2.- Three-view drawing of D-558-1 airplane.

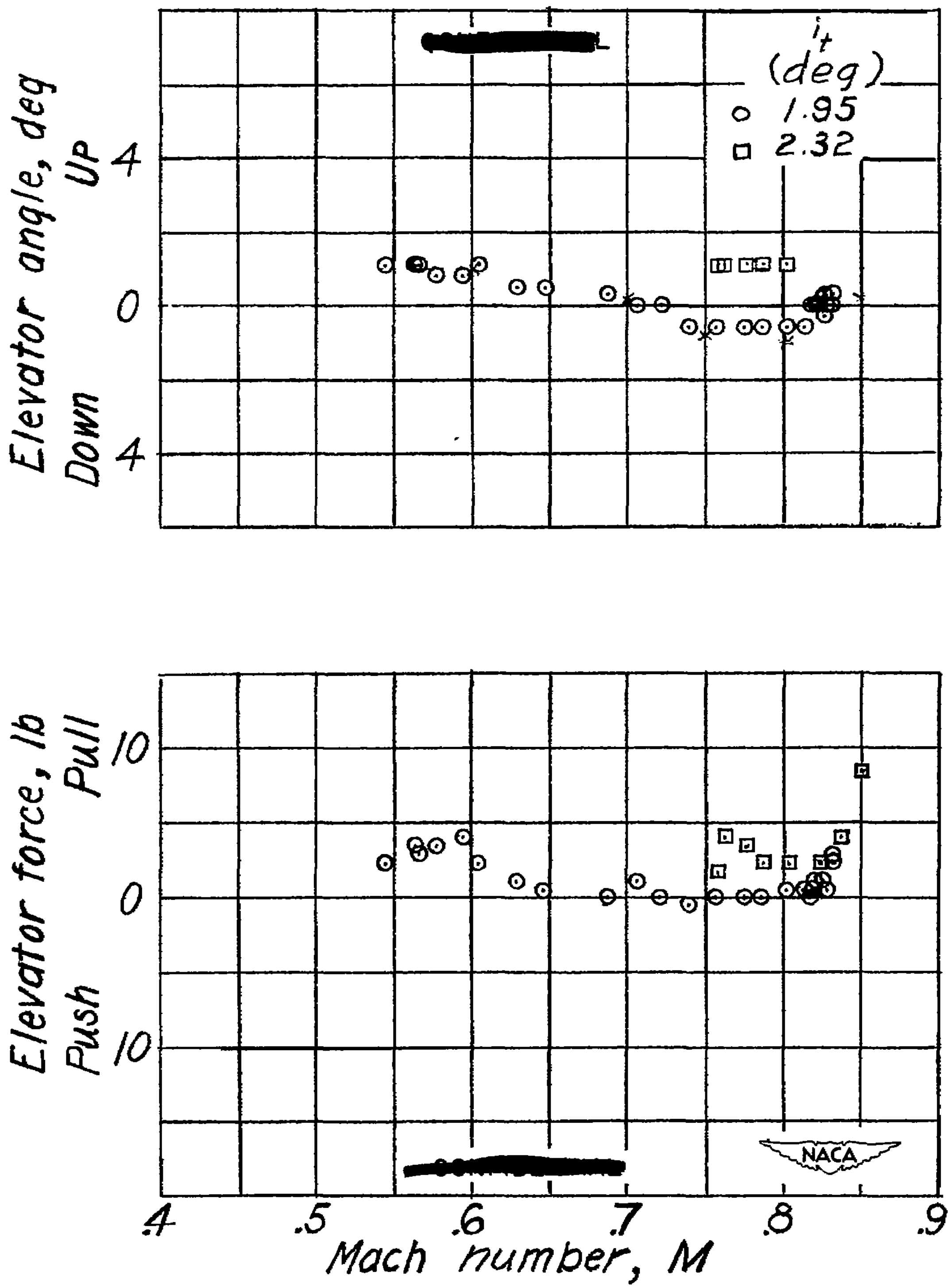


Figure 3.- Variation of elevator position and force with Mach number at 30,000 feet. D-558-1 airplane.